Appendix

This appendix provides supplemental and technical information about our methods for estimating underwriting decisions for Americans ages 50-71 in our paper, "Medical Underwriting In Long-Term Care Insurance: Market Conditions Limits Options For Higher-risk Consumers." We also include here sensitivity analyses and additional data summary.

1 Underwriting Process

Figure A.1 shows steps that consumers go through before they become holders of long-term care insurance policies. While many people do not shop for policies because they do not think it is necessary or find it unaffordable, a large portion are excluded in the underwriting stages.

Because the application process is time-consuming and costly, agents typically do not market long-term care insurance to prospective buyers over the age of 70, where underwriting rejection rates can be high, and steer those who already exhibit some other easily determined disqualifying condition away from the process. For example, in a guide for insurance agents developed by one of the largest carriers of long-term care insurance, agents are instructed to discourage applications from individuals who are morbidly obese or who have been diagnosed with one of a list of conditions such as multiple sclerosis, Alzheimer's disease, cirrhosis of the liver, or Parkinson's disease,[1] conditions that would put the individual at high risk for immediate need of long-term care services. Most state regulations require agents to verify that their clients' income and assets meet minimum thresholds for the premiums to be financially suitable. As part of the initial meeting, carriers in these states (and most carriers even in states where it is not required by law) have their agents counsel clients—usually in the form of a personal worksheet—as to whether their assets and income are sufficient for long-term care insurance to be a suitable financial product for them. The rule of thumb proposed by the National Association of Insurance Commissioners (NAIC) is that that if the client is currently eligible for Medicaid or has less than $30,000 in assets, or if the premium amount would be more than 7% of their income, then long-term care insurance may not be appropriate.[2]

[1] Genworth Life Insurance Company [Internet]. TrueView Underwriting Guide. Richmond, VA; 2013 Mar 15 [cited 2015 December 10]. Available from: `http://www.ltcforagents.com/carriers/genworth/Underwriting_Guides/Genworth_Underwriting_Guide_52013.pdf`

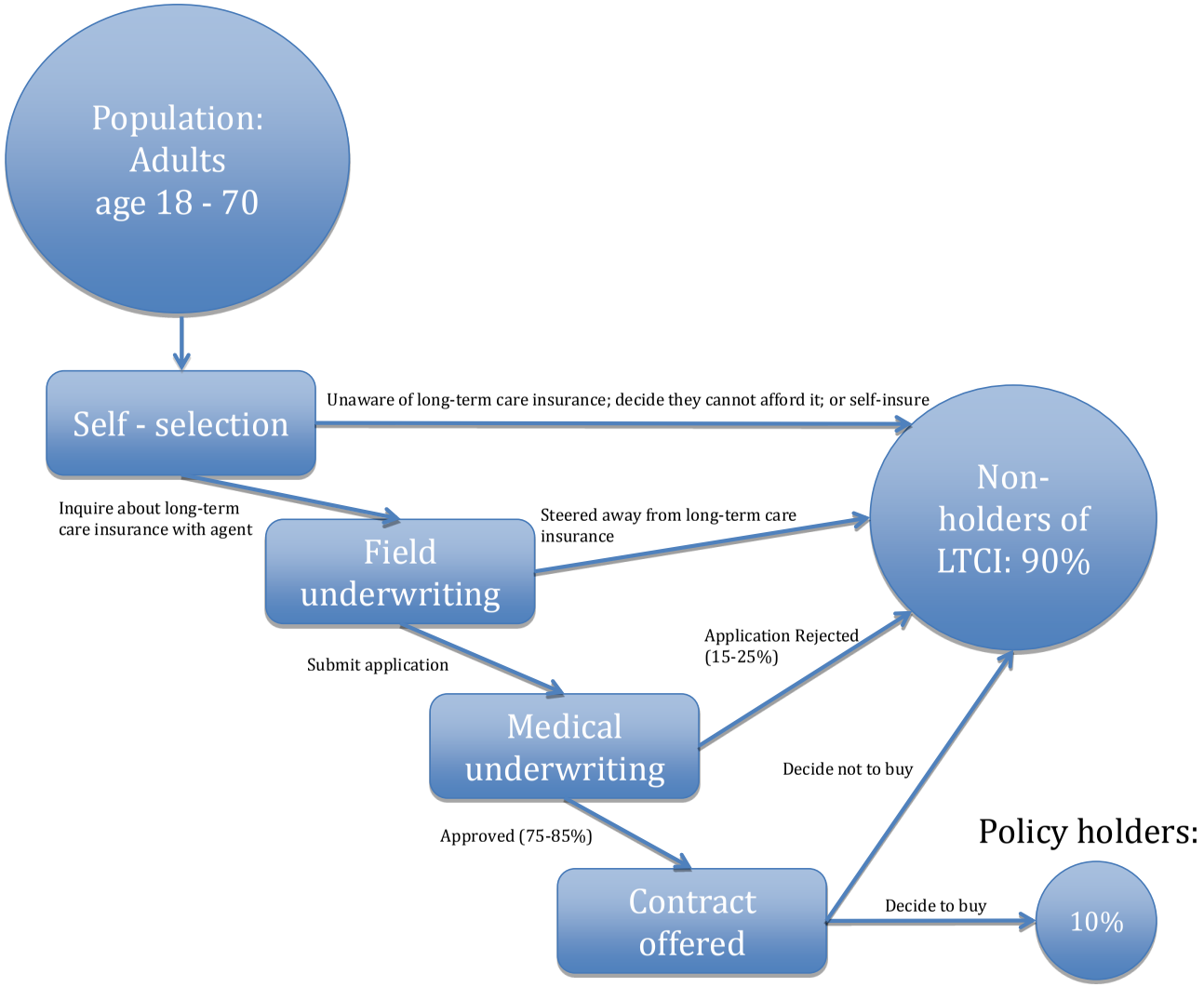
[2] Long-term Care Insurance Model Regulation. National Association of Insurance Commissioners.

For individuals who submit a formal application, the underwriting assessment starts with a questionnaire. In certain situations, insurers may also request medical records from attending physicians, conduct telephonic interviews or home visits, and perform pharmacy database searches as part of the medical underwriting process. Underwriting accuracy confers a competitive advantage in the marketplace, and standards and protocols vary across companies and are protected as confidential company assets. These screens can include comprehensive screening of mobility, activities of daily living (ADLs) and instrumental activities of daily living (IADLs), cognitive screening, medical history, living environment and clinical observations. At the beginning of the long-term care insurance purchasing process, selling agents discourage applications from buyers who have easily determined disqualifying conditions or have insufficient income or assets for premiums to be financially suitable. For individuals who submit formal applications, the underwriting assessment starts with a health history questionnaire. To verify applicants' information and collect more detailed information, insurers may request medical records or conduct telephone interviews or home visits. For qualifying applicants, firms offer a premium rate and coverage terms for consideration. Firms tend to offer age- and (more recently) gender-rated standard premium rates. Health is taken into account in deciding whether to offer coverage at all, and in some cases whether to provide a discount or added premium to a base premium rate.

After a reviewer with clinical training examines the applicant's file and makes a coverage recommendation, the applicant receives an offer of coverage with premium amounts and makes a decision to purchase. Firms tend to offer age- and (more recently) gender-rated standard premium rates, taking health into account only in deciding whether to accept or decline an applicant; they generally do not consider it in setting premiums for those they accept. When health is taken into consideration, some firms may offer discounts for being in a preferred risk class—for example, for no use of tobacco, having blood pressure and body weight in the healthy range, and being physically active—whereas the less healthy may be accepted into a substandard risk class at significantly higher premiums. We do not have information on whether the carriers in our study offered differentiated premiums.

Model regulation service; 2014 Oct [cited 2015 July 29]. Available from: `http://www.naic.org/prod_serv_model_laws.htm`

Exhibit A.1: Medical underwriting process



2 Methods

2.1 Data

Data Collection. The insurance data were collected by a full service third party administrator (TPA) that made underwriting decisions on behalf of these companies. Insurance firms collected information with written, self-administered questionnaires from applicants and sent them to the TPA where a clinician reviewed each applicant's file and offered a recommendation to "approve" or "not approve" the application. Although the applicants' answers were not independently verified, the insurer's right to rescind a policy based on fraud or material misrepresentation (generally only within the first two years after policy issue) gives applicants the incentive to report their health status in good faith. We use a sub-set of the characteristics that correspond to items in the Health and Retirement Study (HRS). Some reported health conditions are aggregated categories from several diagnoses or self-reported conditions (see Exhibit A.2). Although employment and education may not be explicitly considered in underwriters' decisions, we nonetheless include these covariates because they can capture some aspects of health and functional status otherwise not measured in the HRS.

Where responses were missing one or more of the underwriting variables, we filled in these values using the Imputation by Chained Equations (ICE) method[3].

Estimates from the HRS are weighted to correspond to the American Community Survey, a nationally representative sample of non-institutionalized adults. Therefore individuals in institutional settings (such as a nursing home) have a weight of 0, and all reported population proportions and prevalence have a denominator comprising individuals living in the community.

Exhibit A.2: Underwriting and HRS variable alignment

Model variable	**Underwriting question**	**HRS (RAND)**	**HRS coding**
Age	Age in years at time of underwriting	ragey_e	Age in years at time of interview
Female	gender	ragender	0 (male), 1 (female)
College degree	>=16 years of education	radegrem	5 (BA)
Employment status	Employed	rwork	1 (currently working for pay)
Delayed word recall <7/10	delayed word recall score < 7/10	rdlrc	delayed word recall score <7/10
Take any medication for depression	Do you take any medication(s) for depression?	rcesd	cesd score >=6

[3]Royston P. Multiple imputation of missing values. Stata Journal. 2004;4(3):227-241.

Exhibit A.2: Underwriting and HRS variable alignment

Model variable	**Underwriting question**	**HRS (RAND)**	**HRS coding**
Experiences memory loss	Do you ever experience Forgetfulness, Memory Loss or Confusion?	rmemry, ralzhe, rdemen	memory problems; Alzheimers problems; dementia problems
Difficulty taking medication	not "independent" for "taking medication"	rmedsa	some difficulty – taking medications
Difficulty with activities of daily living	not "independent" for any of the following: transferring, toileting, bathing, dressing, eating, mobiliy inside	radla	"some difficulty" with 1 or more of the following: bathikng, dressing, eating, getting out of bed, walking across a room
High blood pressure	High blood pressure	rhibpe	ever had high blood pressure
Back pain	Back or Spine Condition Pain andor Swelling in your Neck Back Spine Shoulders A	rback	had back problems
Arthritis	Degenerative Bone or Joint Disease/Arthritis	rarthre	ever had arthritis
Diabetes	Diabetes	rdiabe	ever had diabetes
Heart problems	Heart/Circulatory Problems AFib or Irregular heart beat Congestive Heart Failure Heart Attack Angina or heart related chest pain	rhearte	ever had heart problems
Psychiatric illness	Psychiatric Disorders Depression Anxiety	rpsyche	Ever had emotional / psychiatric problems
Lung problems	COPD / Emphysema / Asthma Shortness of Breath / Difficulty Breathing Sleep Apnea	rlunge	ever had lung disease

Exhibit A.2: Underwriting and HRS variable alignment

Model variable	**Underwriting question**	**HRS (RAND)**	**HRS coding**
Cancer	Cancer Leukemia Lymphoma or Melanoma Hodgkins Disease	rcancre	ever had cancer
Stroke	Stroke / TIA / mini Stroke Peripheral Vascular Disease	rstroke	ever had stroke
Hospitalization, previous 2 years	Have you been hospitalized or received any medical care within the past 3 years?	rhosp	1 (hospital stay, prev. 2 years)
Long-term care, previous 2 years	In the Past 2 years have you been confined to a nursing home or received any adult day care, short term care or home care services?	rnrshom	Nursing home stay, prev 2 years
		rhomcar	Home health care, prev 2 years

2.2 Analysis

To estimate underwriting approval probabilities for the general population, we developed an empirical model of the coverage decision using underwriting data from the long-term care-insurance carriers and applied the model parameters to a nationally representative sample of older US residents. We report a linear probability model of underwriting approval, estimated using ordinary least squares, to facilitate an intuitive interpretation of the percentage-point effect on probability of approval of each characteristic and health condition. The model is as follows:

$Y_i = X_i\beta + \epsilon_i$

Where Y is 1 for approved and 0 for disqualified applicants, and X is the vector of applicant characteristics (age categories, health conditions, etc.), and ϵ is a randomly distributed error term.

Those results, with standard errors, are displayed in Column 1 of Exhibit A.4 with standard errors, and correspond to Exhibit 1 of the main article.

We estimated the probability of underwriting approval using the generalized linear model:

$Pr(Y_i = 1) = F(X_i\beta^*)$

Where F is the logistic function. Results with 95% confidence intervals are shown in

Exhibit A.5. Column 2 of Exhibit A.4 shows the population-averaged marginal effects of X (using the Stata *margeff* command), with standard errors calculated using the delta method, where each estimate is the difference in approval rate for the entire sample between $X_{i,k} = 0$ and $X_{i,k} = 1$. These are similar to the OLS estimates.

To estimate individual probabilities we specified a model with indicators for each age-year value, interaction terms of gender with age, and a variable for the number of health conditions (1, 2, and 3 or more), as reported in Exhibit A.5, column 2. For each individual in the HRS sample, we calculate $\hat{p} = F(X_i^{HRS}\beta^*)$ for each respondent in the HRS sample to predict the probability they would be offered a policy, supposing they were to apply for insurance subject to similar underwriting conditions.

To summarize the results, for each sub-sample s we report both the mean of the predicted probabilities ($\bar{\hat{p}}^s$), and the percent of the sample that is likely approved ($\hat{\pi}^s_{appr}$), where:

$\bar{\hat{p}}^s = \frac{1}{n}\sum_{i=1}^{n} \hat{p}^s$

$\hat{\pi}^s_{appr} = \frac{1}{n}\sum_{i=1}^{n} I(\hat{p}^s >= 0.5)$

We generated the approval probability models with Stata version 13 and estimated survey statistics and generated figures with R version 3.1.3.

3 Results

3.1 Main results

Exhibit A.3 gives the prevalence estimates of the underwriting variables for the insurance sample (disqualified, approved, and full sample) and for the HRS respondents. Exhibit A.4 shows the differential, linear effect of a change from 0 to 1 for these variables and their standard errors. Column 1 shows the change in probability from a linear probability model estimated using ordinary least squares (reported in the main article, exhibit 1), and column 2 shows the average change in probability from the logistic regression model,with standard errors calculated using the delta method, using the MFX command in stata. Exhibit A.5 shows the odds ratio estimates from logistic models of the probability of approval. Column 2 contains the full specification of the model we used to impute probabilities, including interaction terms, fixed effects for each year of age, and indicators for 2 and 3-or-more of the chronic conditions in the model. Exhibit A.6 summarizes the imputed estimates for the HRS sample corresponding to Exhibit 2 in the main article.

Exhibit A.3: Summary statistics

	Disqualified	Approved	All Applicants	HRS
Age 18 - 49	0.122	0.231	0.205	0.000
Age 50 - 59	0.341	0.424	0.404	0.528
Age 60 - 69	0.484	0.320	0.360	0.415
Age 70 up	0.053	0.024	0.031	0.057
Female	0.449	0.486	0.477	0.523
Education 16+ years	0.476	0.550	0.532	0.313
Employed	0.625	0.756	0.725	0.587
Word recall score < 7	0.300	0.229	0.246	0.831
Self-reported memory loss	0.236	0.159	0.177	0.217
Difficulty taking medication	0.016	0.006	0.009	0.025
Difficulty with 1+ ADL	0.004	0.000	0.001	0.122
High blood pressure	0.502	0.279	0.333	0.494
Back pain	0.409	0.232	0.275	0.389
Arthritis	0.245	0.102	0.137	0.466
Diabetes	0.201	0.026	0.069	0.183
Heart problems	0.199	0.082	0.110	0.160
Psychiatric illness	0.184	0.092	0.115	0.195
Lung problems	0.102	0.050	0.062	0.080
Cancer	0.057	0.027	0.034	0.100
Stroke	0.016	0.001	0.004	0.046
Hospitalization, prev 2 years	0.533	0.353	0.396	0.213
Long-term care, prev 2 years	0.016	0.004	0.007	0.054
Drinks alcohol	0.890	0.903	0.900	0.655
Ever been a smoker	0.379	0.296	0.316	0.568
Current smoker	0.085	0.053	0.060	0.187
Underweight	0.007	0.005	0.005	0.010
Normal/Overweight	0.595	0.743	0.707	0.614
Obese	0.374	0.247	0.278	0.322
Extremely obese	0.024	0.005	0.010	0.054
Observations	3782	11877	15659	13770

Source:
Notes:

Exhibit A.4: Marginal effects

Marginal effects on probability of approval

	OLS	MFX
Age 50 - 59	-0.007	-0.014
	(0.008)	(0.009)
Age 60-69	-0.037***	-0.042***
	(0.009)	(0.010)
Age 70+	-0.081***	-0.073***
	(0.020)	(0.020)
Female	0.016**	0.015**
	(0.007)	(0.007)
Education 16+ years	0.020***	0.020***
	(0.006)	(0.006)
Employed	0.030***	0.028***
	(0.008)	(0.007)
Word recall score < 7	-0.035***	-0.033***
	(0.007)	(0.007)
Self-reported memory loss	-0.020**	-0.017**
	(0.008)	(0.008)
Difficulty taking medication	-0.094***	-0.071**
	(0.033)	(0.028)
Difficulty with 1+ ADL	-0.522***	-0.402***
	(0.092)	(0.097)
High blood pressure	-0.078***	-0.070***
	(0.007)	(0.006)
Back pain	-0.101***	-0.090***
	(0.007)	(0.006)
Arthritis	-0.111***	-0.086***
	(0.009)	(0.008)
Diabetes	-0.415***	-0.297***
	(0.012)	(0.010)
Heart problems	-0.130***	-0.104***
	(0.010)	(0.009)
Psychiatric illness	-0.123***	-0.105***
	(0.010)	(0.008)
Lung problems	-0.086***	-0.070***
	(0.013)	(0.011)
Cancer	-0.111***	-0.090***
	(0.017)	(0.015)
Stroke	-0.528***	-0.435***
	(0.046)	(0.055)
Hospitalization, prev 2 years	-0.065***	-0.063***

Exhibit A.4: Marginal effects

Marginal effects on probability of approval

	OLS	MFX
	(0.007)	(0.006)
Long-term care, prev 2 years	-0.083**	-0.050
	(0.037)	(0.032)
Drinks alcohol	0.024**	0.023**
	(0.010)	(0.010)
Ever been a smoker	-0.013*	-0.014**
	(0.007)	(0.007)
Current smoker	-0.114***	-0.104***
	(0.013)	(0.012)
Underweight	-0.174***	-0.188***
	(0.042)	(0.050)
Obese	-0.046***	-0.044***
	(0.007)	(0.007)
Extremely Obese	-0.268***	-0.258***
	(0.031)	(0.038)
Constant	0.920***	
	(0.015)	
Observations	15659	15659
R-squared	0.22	
F-statistic	159	

Source: Authors' analysis data on applicants for long-term care insurance for two US firms in 2009 - 2011.

Notes: Table displays marginal effects of characteristics on probability of underwriting approval, with standard errors shown in parentheses. OLS is a linear probability model estimated with ordinary least squares (OLS). Model 2 is the marginal effects estimated from logistic regression shown in Table A.5. The reference category for age is the 18 – 49 age group. Reference category for BMI categories is normal/overweight.

*$p < .05$, **$p < .01$, ***$p < .001$

Exhibit A.5: Models to estimate marginal effects and predict underwriting probabilities

	(1)	(2)
Age 50 - 59	0.901	
	[0.793,1.022]	
Age 60-69	0.743***	
	[0.648,0.852]	
Age 70+	0.613***	
	[0.479,0.783]	
Female	1.110**	0.931
	[1.013,1.216]	[0.751,1.154]
Education 16+ years	1.147***	1.156***
	[1.052,1.249]	[1.060,1.260]
Employed	1.213***	1.164***
	[1.097,1.341]	[1.050,1.291]
Word recall score < 7	0.795***	0.801***
	[0.723,0.873]	[0.728,0.880]
Self-reported memory loss	0.890**	0.880**
	[0.801,0.989]	[0.792,0.979]
Difficulty taking medication	0.609**	0.638**
	[0.413,0.899]	[0.432,0.941]
Difficulty with 1+ ADL	0.060***	0.054***
	[0.016,0.226]	[0.014,0.209]
High blood pressure	0.611***	0.745***
	[0.559,0.668]	[0.605,0.916]
Back pain	0.531***	0.632***
	[0.485,0.581]	[0.514,0.777]
Arthritis	0.548***	0.597***
	[0.491,0.613]	[0.484,0.736]
Diabetes	0.125***	0.143***
	[0.107,0.145]	[0.113,0.181]
Heart problems	0.483***	0.549***
	[0.429,0.544]	[0.443,0.679]
Psychiatric illness	0.478***	0.545***
	[0.425,0.538]	[0.439,0.675]
Lung problems	0.610***	0.664***
	[0.523,0.711]	[0.528,0.835]
Cancer	0.530***	0.618***
	[0.433,0.648]	[0.473,0.808]
Stroke	0.047***	0.053***
	[0.022,0.102]	[0.024,0.115]
Hospitalization, prev 2 years	0.643***	0.653***
	[0.590,0.701]	[0.599,0.712]

Exhibit A.5: Models to estimate marginal effects and predict underwriting probabilities

	(1)	(2)
Long-term care, prev 2 years	0.705	0.675*
	[0.457,1.090]	[0.439,1.039]
Drinks alcohol	1.177**	1.164**
	[1.023,1.355]	[1.011,1.341]
Ever been a smoker	0.908**	0.930
	[0.826,0.997]	[0.846,1.023]
Current smoker	0.483***	0.481***
	[0.411,0.568]	[0.408,0.567]
Underweight	0.329***	0.312***
	[0.198,0.544]	[0.185,0.526]
Obese	0.740***	0.732***
	[0.675,0.811]	[0.668,0.803]
Extremely Obese	0.232***	0.228***
	[0.160,0.336]	[0.157,0.331]
1 health condition		0.539***
		[0.430,0.677]
2 health conditions		0.473***
		[0.318,0.704]
3 health conditions		0.575*
		[0.307,1.079]
Constant	10.563***	15.863***
	[8.522,13.093]	[12.370,20.341]
Observations	15659	15659
Pseudo R-squared	0.19	0.20
Akaike's Inf. Crit.	14113	14036
Bayesian Inf. Crit.	14328	14587
Log-likelihood	-7029	-6946

Source: Authors' analysis of the Health and Retirement Study.

Notes: We modeled probability of approval in a multivariate logistic regression. Exponentiated odds ratios are shown with 95% confidence intervals in brackets. Model 1 is the specification for marginal effects reported in Table A.4. Model 2 is used to impute probabilities in the HRS sample, and includes fixed effects for each year of age, and age-female interactions (coefficients not shown). The reference category for age and age-female interactions is the 18 – 49 age group. *$p < .05$, **$p < .01$, ***$p < .001$

4 Model checks

4.1 Sensitivity analyses

Exhibits A.7 and A.8 shows how the results vary with different probability thresholds for designating a respondent as "likely approved." We chose 0.5 as the cutoff because it has the strong advantage of appealing to common-sense intuition: above .5, an individual is more likely than not to be approved, and below, less likely. But some empirical context is also useful. The purpose of the analysis is to estimate an upper bound on how many individuals in the population would be able to pass underwriting requirements similar to these. Figure A.8 give a picture of the sensitivity of the estimated approval rate to the threshold we assign to "approved." If the .5 threshold is applied to the insurance sample, then the predicted approval rate in that sample is approximately 88%. That approval rate is higher than both the actual acceptance rate for this sample of 76% and another recent estimate of the industry-wide average of 81%. As one would expect, the predicted approval rates for the general population (HRS) sample are especially sensitive to the choice of threshold probability, as these individuals are generally less healthy than the insurance sample population. Table A.7 show how the estimates by financial category change with different threshold assumptions.

4.2 Generalizability of insurance sample to the industry

The companies in our insurance sample represent approximately 5% of market share for new policies issued over the study period. One firm may apply underwriting criteria differently from another, so our analysis assumes that the underwriting decisions that we model from this sample reflect, on aggregate, similar proportion of approved applicants to the industry as a whole. The rejection rate that we observe in this sample, 24%, is somewhat higher than the 19% rejection rate that another recent study found in a survey of companies that represented about 70% of the market.[4] Exhibit A.9 shows the declination rates, by age group, of that industry sample Differences could originate from stricter underwriting standards at the firms that supplied our sample or more variation in health status among the applicant pool. Our model, however, predicts a rejection rate in the insurance sample of only 12%. That suggests that our model produces a conservative lower bound of the proportion of the population that would be disqualified if industry-wide criteria were applied to the population at large.

[4]LifePLans, Inc. *Appendix J: A profile of declined long-term care insurance applicants.* In: *A Report on the Actuarial, Marketing, and Legal Analysis of the CLASS Program.* Washington, DC: Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation, Office of Disability, Aging, and Long-Term Care Policy. 2010 December 27 [cited 2015 May 1]. Available from: https://aspe.hhs.gov/sites/default/files/pdf/76321/appJa.pdf.

Exhibit A.6: Summary of imputed estimates of underwriting approval for long-term care insurance

Category of suitability of long-term care insurance for respondent[c]	Sample size	Population, millions (SE)[a]	Mean approval probability[a]	pct likely to be approved[a,b]
Suitable	6166	37.98 (2.43)	0.611 (0.006)	70.1 (0.83)
Assets $30,000 - $250,000	3361	19.50 (1.20)	0.580 (0.008)	65.6 (1.07)
Assets over $250,000	2805	18.48 (1.23)	0.644 (0.007)	74.9 (1.00)
Not suitable	7604	33.08 (1.64)	0.441 (0.005)	47.4 (0.78)
Full sample	13770	71.07 (4.07)	0.532 (0.005)	59.6 (0.71)

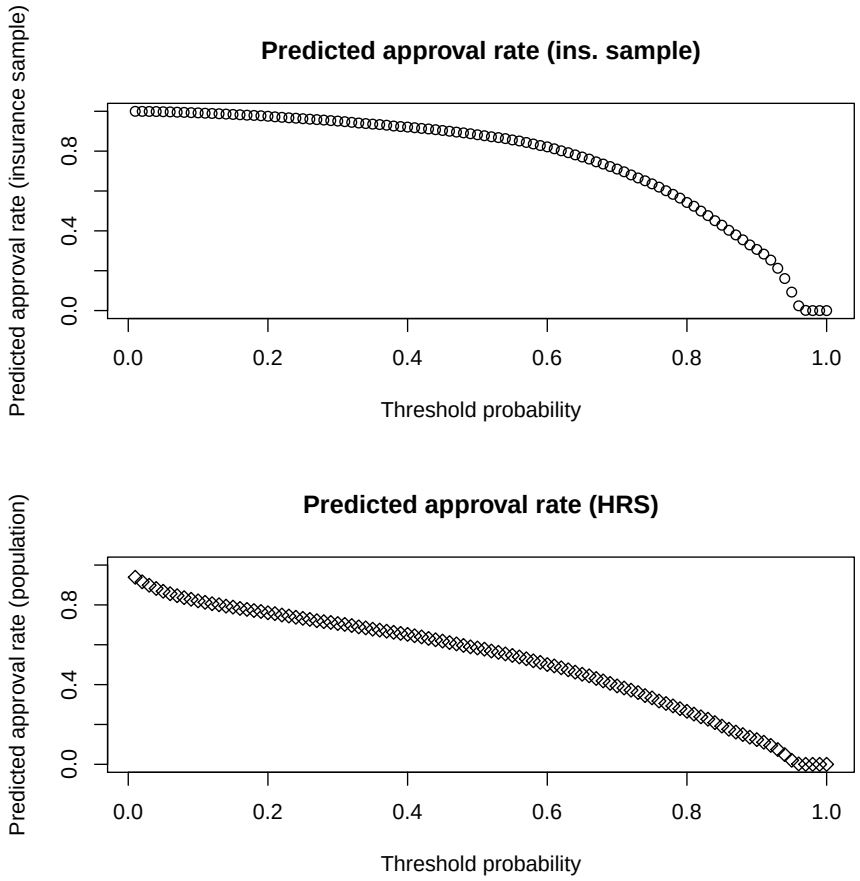
Source Authors' analysis of the Health and Retirement Study (HRS), 2010-2011, respondents ages 50 – 71.
Notes Probability estimates for HRS respondents were predicted from a multivariate logistic regression model, summarized in Exhibit 2, that the authors estimated from approval information on the insurance applicants. The full model with odds ratios is available in an online appendix (18). (a) Population estimates were weighted to correspond to the American Community Survey, a sample of non-institutionalized U.S. adults. Standard errors (in parentheses) account for the sampling design of the HRS and variance of the imputed probabilities and not modeling uncertainty from the prediction model. (b) Respondents were designated as "likely to be approved" with imputed approval probability > 0.5. Thus the percentage reported in this column represents the estimated population proportion with predicted approval > 0.5. (c) Financial suitability of long-term care insurance for the respondent is defined as household yearly income¿$20,000 and non-housing assets¿$30,000 for a single person, and respectively $30,000 and $50,000 for a couple.

Exhibit A.7: Imputed estimates of underwriting approval for long-term care insurance: sensitivity analyses

Category of suitability of long-term care insurance for respondent[c]	pct likely to be approved[a,b]				
Threshold probability	0.4	0.45	0.5	0.55	0.6
Full sample	66.2% (0.72)	63.0% (0.75)	59.6% (0.71)	55.6% (0.72)	50.7% (0.70)
Suitable	76.2% (0.80)	73.5% (0.88)	70.1% (0.83)	66.2% (0.81)	61.0% (0.90)
Assets $30,000-250,000[d]	72.0% (1.12)	69.0% (1.18)	65.6% (1.07)	61.0% (1.09)	56.2% (1.16)
Assets $250,000 and over[d]	80.8% (0.82)	78.4% (0.89)	74.9% (1.00)	71.6% (1.06)	66.0% (1.17)
Not suitable	54.6% (0.86)	51.0% (0.83)	47.4% (0.78)	43.3% (0.73)	38.9% (0.72)

Source Authors' analysis of the Health and Retirement Study (HRS), 2011-2012, ages 50 – 71. **Notes** Probability estimates for HRS respondents were predicted from a multivariate logistic regression model, summarized in Appendix Table A.5, that the authors estimated from approval information on the insurance applicants. (a) Population estimates were weighted to correspond to the American Community Survey, a sample of non-institutionalized U.S. adults. Standard errors (in parentheses) account for the sampling design of the HRS and variance of the imputed probabilities and not modeling uncertainty from the prediction model. (b) Respondents were designated as "likely to be approved" with imputed approval probability below the threshold, and as likely to be disqualified with imputed probability above the threshold. Thus the percentage reported in the first column represents the estimated population proportion with predicted approval >0.4, etc. (c) Financial suitability of long-term care insurance for the respondent is defined as household yearly income>20,000 and non-housing assets>$30,000 for a single person, and respectively $30,000 and $50,000 for a couple. (d) Assets include the net total of all non-housing assets: property, business assets, other real estate, and financial wealth (including retirement accounts), less non-mortgage debt.

Exhibit A.8: Sensitivity of estimates to assumed approval threshold



Data source: Authors' analysis of data on applicants from two U.S. insurance firms in 2009-2012 (N=15659), the Health and Retirement Study, 2010-2011 (N=13770).
Notes: Figures show the proportion of the sample "likely approved" with change in assumed threshold for approval. Y-axis is the imputed probability, and X-axis is the designated threshold.

Exhibit A.9: Comparison of analytic sample with industry declination rates by age group

	Industry Insurance Sample	Analytic Insurance Sample		
Age	Declined	Declined	Predicted probability	Predicted Declined
0-44	0.07	0.13	0.13	0.02
45-49	0.09	0.16	0.15	0.03
50-59	0.12	0.20	0.20	0.07
60-64	0.16	0.29	0.29	0.16
65-69	0.22	0.38	0.38	0.28
70-74	0.27	0.41	0.41	0.32
Mean	0.14†	0.24	0.24	0.12

Source: Industry sample is composed of survey responses from 15 long-term care insurance firms, constituting 70% of the total market‡.

Notes:

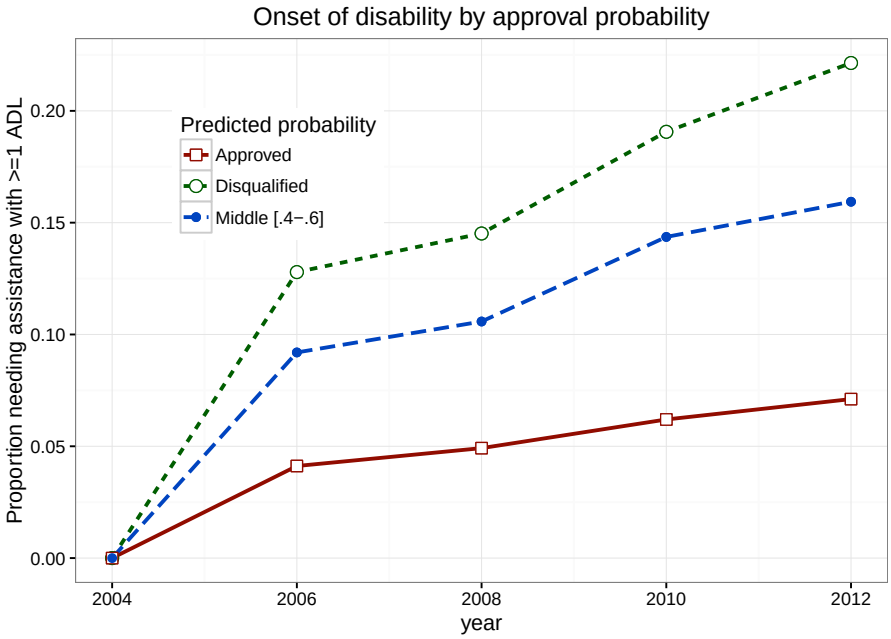
† The overall industry mean reported in the study was 0.19. The mean we give here is weighted by age category to match the age distribution of applicants in our insurance sample.

‡LifePLans, Inc. *Appendix J: A profile of declined long-term care insurance applicants.* In: *A Report on the Actuarial, Marketing, and Legal Analysis of the CLASS Program.* Washington, DC: Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation, Office of Disability, Aging, and Long-Term Care Policy. 2010 December 27 [cited 2015 May 1]. Available from: https://aspe.hhs.gov/sites/default/files/pdf/76321/appJa.pdf.

4.3 Disability and underwriting models

We plotted the incidence of disability in Figure A.10, starting with a cohort reporting 0 ADLs (figure in appendix). Approved are individuals with predicted probability > 0.5 (N=7545) and disqualified < 0.5 (N=3778). Starting with a cohort of individuals with no ADL needs, the figure shows the cumulative incidence of disability (here defined as at least 1 ADL need) over 8 years. The figure gives some sense of how predictive the underwriting models are of near-term disability that might invoke long-term care benefits. The "marginal" group, with probabilities between 0.4 and 0.6, may be potentially insurable with lower risk than the "Disqualified" group, but is also higher risk. One interpretation of this figure is that firms are fairly accurate with underwriting determinations, and yet there may be some potential for policies that reduce adverse selection to allow that middle group to buy insurance.

Exhibit A.10: Underwriting models and incidence of disability



Data source: Authors' analysis of the Health and Retirement Study, 2004 – 2012 (waves 7 – 11). Approved are individuals with predicted probability >0.5 (N=7545) and disqualified <0.5 (N=3778). **Notes:** Figure shows the cumulative incidence of disability, defined as needing assistance with at least 1 activity of daily living (ADL). Sample comprises individuals in the Health and Retirement Study. Estimates are weighted to match the Current Population Survey.

4.4 Insurance purchase and underwriting models

As a check on our model (Table A.11), we examine how purchase of new LTCI policies varies with predicted approval probability. When we look at the relationship between insurance take-up from the 2012 to 2014 period among individual who do not hold insurance in 2012, we find that higher approval probability is weakly associated with higher insurance take-up. Using individuals who report not owning an LTCI policy waves 3 – 11 of the HRS (spanning 1996 – 2014), we find that having approval probability over 0.5 is associated with 1%-point higher chance of buying insurance, approximately 33% higher than those with approval probability under 0.5 ($p < 0.01$).

While the positive sign is encouraging, it is problematic to infer anything about the accuracy of the model from the magnitude of the relationship because demand is endogenous to health. With additional years of age or new health shocks, individuals probably become more aware of their potential need for long-term care insurance and more likely to seek it out, and also less likely to qualify if they do apply. To properly test the effect of underwriting on uptake, we would need some way to observe demand conditional on health and age, or a source of exogenous variation in demand (such as price shocks). Additionally, in the HRS we can't distinguish between policies bought on the group and non-group markets, which have different underwriting standards.

Exhibit A.11: Association of take up of new long-term care Insurance with high approval probability

	Dependent variable:
	New LTCI policy
Likely approved	0.010***
	(0.001)
Constant	0.031***
	(0.001)
Observations	141,012
R^2	0.001
F Statistic	98.791*** (df = 1; 141010)
Note:	*p<0.1; **p<0.05; ***p<0.01